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Research paper

Cretaceous alkaline volcanism in south Marzanabad, northern central Alborz, Iran: Geochemistry and petrogenesis

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ABSTRACT

The alkali-basalt and basaltic trachy-andesites volcanic rocks of south Marzanabad were erupted during Cretaceous in central Alborz, which is regarded as the northern part of the Alpine-Himalayan orogenic belt. Based on petrography and geochemistry, en route fractional crystallization of ascending magma was an important process in the evolution of the volcanic rocks. Geochemical characteristics imply that the south Marzanabad alkaline basaltic magma was originated from the asthenospheric mantle source, whereas the high ratios of $(La/Yb)_N$ and $(Dy/Yb)_N$ are related to the low degree of partial melting from the garnet bearing mantle source. Enrichment pattern of Nb and depletion of Rb, K and Y, are similar to the OIB pattern and intraplate alkaline magmatic rocks. The K/Nb and Zr/Nb ratios of volcanic rocks range from 62 to 588 and from 4.27 to 9 respectively, that are some higher in more evolved samples which may reflect minor crustal contamination. The isotopic ratios of Sr and Nd respectively vary from 0.70370 to 0.704387 and from 0.51266 to 0.51281 that suggest the depleted mantle as a magma source. The development of south Marzanabad volcanic rocks could be related to the presence of extensional phase, upwelling and decompressional melting of asthenospheric mantle in the rift basin which made the alkaline magmatism in Cretaceous, in northern central Alborz of Iran.

1. Introduction

Plutonic or volcanic alkaline rocks are typically associated with continental rifting or intraplate continental and oceanic settings that typically related to the partial melting of asthenospheric mantle (McKenzie and Bickle, 1988; White and McKenzie, 1989; Wilson and Downes, 1991; Ernst et al., 2005; Ganguly, 2005; Lustrino and Carminati, 2007).

Fractional crystallization, magma mixing and crustal contamination are the main processes in the evolution of magmas (Best, 1970; Wilson, 1989; Hall, 1996; Rollinson, 1998; McBirney, 2006). The effect of these processes in magmatism in orogenic belts, could be cleared by geochemistry and petrology studies.

Marzanabad area in northern part of central Alborz is a part of Alpine-Himalayan orogenic that formed in Cretaceous with well developed sub-marine alkaline volcanic sequences. The volcanism associated with Barremian–Aptian and Cenomanian limestone layers clarified Cretaceous age for volcanic rocks (Cartier, 1971; Sussli, 1976; Vahdati Daneshmand and Nadim, 2001), while there are no corresponding radiometric ages available.

In Marzanabad area, the outcrops of volcanic rocks, allow us to investigate the Cretaceous volcanism of Alpine Himalayan orogenic belt in Iran. Little is known on Paleozoic and Mesozoic igneous activity in central Alborz, whereas only few aspects are known for the Cenozoic activity. However, neither whole-rock geochemistry nor microprobe or isotopic data have been published for the volcanic rocks of Marzanabad area. In this study, major and trace element, microprobe and Sm-Nd isotopic data are used to constrain the role of fractional crystallization and mantle source in the petrogenesis of alkaline magma from Marzanabad area, central Alborz.

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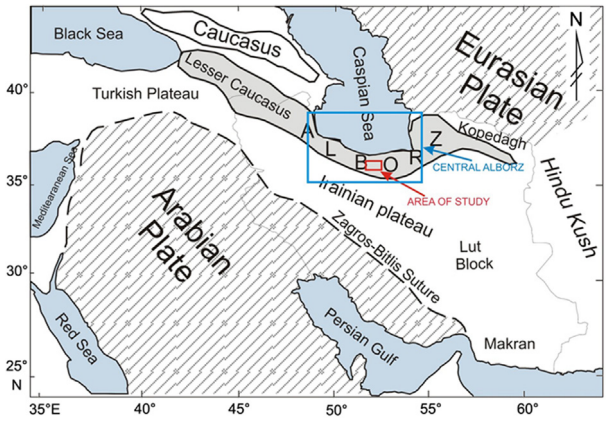

Figure 1. General tectonic map of Iran with Arabian and Eurasian plate and the location of studied area in central Alborz zone.

Results of this study may help to have a better understanding of Cretaceous alkaline magmatism that produced the alkaline volcanic rocks in Alpine Himalayan orogenic belt in central Alborz.

2. Geodynamics background

Central Alborz was a part of the Gondwana plate in early Paleozoic. It separated from Gondwana during Ordovician to Silurian and then collided with Eurasian plate in Triassic, causing the Paleotethys Ocean closure to the north, and the formation of the Neotethys Ocean to the south (Stocklin, 1974; Berberian and King, 1981; Stampfli et al., 1991). After the Triassic collisional event, along both sides of the Paleotethys Ocean, intracontinental compressions were initiated and accompanied by deposition of coal bearing Shemshak Jurassic formation (Berberian, 1983). Compressional tensions coupled with some regional extensional pressures, which were caused by the convergence of Arabian and Eurasian plates (Zanchi et al., 2006).

In central Alborz, Mesozoic era began with the deposition of detrital carbonate sediments which is continued with deposition of Shemshak Formation in late Triassic. In the studied area, extensional phases were started in upper Triassic associated with alkaline igneous activity. This alkaline magmatic phase can be assumed as an evidence for intracontinental tectonic setting related to a rift system in central Alborz during late Triassic (Furon, 1941; Steiger, 1966; Taraz, 1974; Annells et al., 1975; Nabavi and Seyed emami, 1977; Kristan-Tollmann et al., 1979; Berberian and King, 1981; Berberian, 1983; Völlmer, 1987; Fauvelet and Eftekhar Nezhad, 1992; Sabzehei, 1993; Brunet et al., 2003; Seyed emami, 2003; Shahidi, 2005, 2008; Nazari and Shahidi, 2011).

In central Alborz, extensional movements started at the same time with Rhaetic rift volcanism and deposition of coal-bearing Shemshak Formation, in Mesozoic era (Berberian, 1983; Nazari et al., 2004). The extensional phases developed some regional rifts which caused volcanism and plutonism activities in central Alborz (Berberian, 1983).

Soffel and Förster (1984) believed that the extensional movements lead to separation of the central Iranian plate from Eurasia plate, during Jurassic. Lithospheric ruptures, tensions and extensions with ascending of asthenospheric plumes and their partial melting caused the development of the rift system in Alborz zone from middle Jurassic to lower Cretaceous. Extension and the rift development could not persist more than few million years since the tectonical movements of Maastrichtian (Laramide) terminated the extension period.

3. Regional geology

Alborz Mountains are a geological structural zone in north of Iran considered as part of the northern margin of the Alpine-Himalayan orogenic belt (Fig. 1). Alborz block is connected to Caucasus Mountains in the northwest and is bounded by Hindu Kush Mountains in the east (Zanchi et al., 2006), that was part of the Gondwana plate in early Paleozoic. During Ordovician to Silurian, Alborz separated from Gondwana and finally collided with the

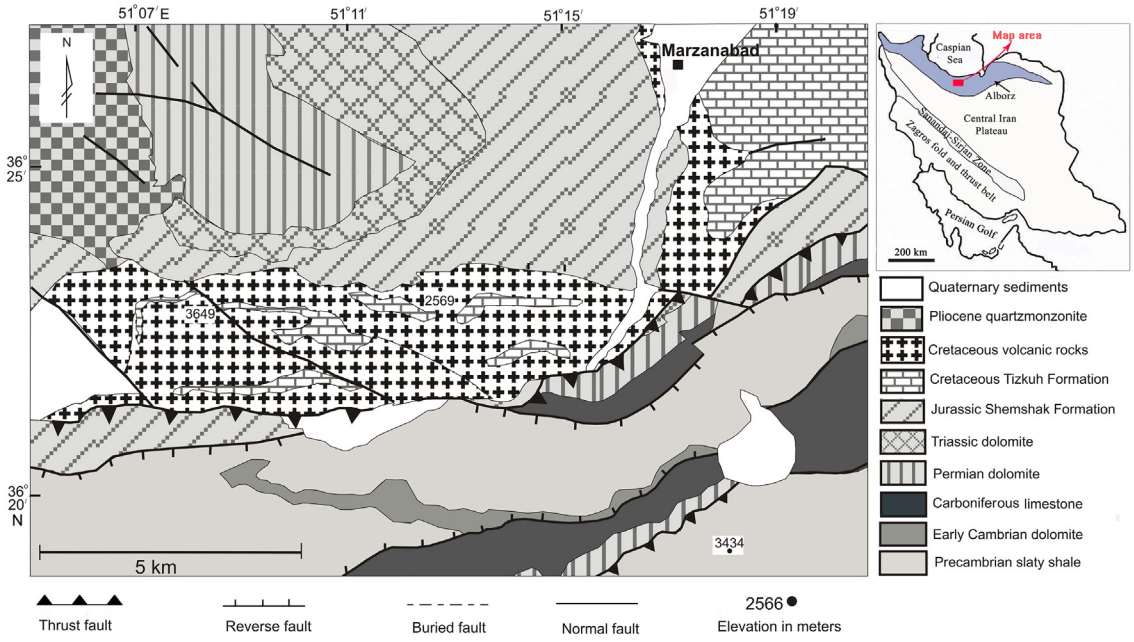

Figure 2. Geological map of the study area with the position of analyzed samples. Modified from the 1:100,000 Marzanabad geological map of Iran.